

The southern limit of *Natrix natrix* in the Levant – a detective story (Squamata: Serpentes: Colubridae)

Die südliche Verbreitungsgrenze von *Natrix natrix*
in der Levante – eine Detektivgeschichte
(Squamata: Serpentes: Colubridae)

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KURZFASSUNG

In einem kleinen Stoß obskurer Veröffentlichungen, reichlich versehen mit unpräzisen Zitaten, könnte sich der Beweis für das einstige Vorkommen von *Natrix natrix* in Israel verborgen. Angesichts der leichten Möglichkeit einer Fehlbestimmung sind einige der relevanten Beobachtungen mit dem Makel behaftet, daß zu ihnen keine Belegexemplare vorliegen. Die mögliche südliche Verbreitungsgrenze scheint sich - vielleicht aufgrund von Umweltveränderungen - seit 1924 um 180 km nach Norden zurückgezogen zu haben.

ABSTRACT

Hidden under a small heap of foggy literature replete with inaccurate quotations, there may exist evidence proving the past occurrence of *Natrix natrix* in Israel. Some relevant observational reports are flawed by the absence of voucher specimens, in the face of easy misidentification. The possible southern distribution limit seems to have regressed 180 km northwards since 1924, perhaps due to environmental changes.

KEY WORDS

Reptilia: Squamata: Serpentes: Colubridae, Natricinae; *Natrix natrix*, distribution, ecology, Levant, Israel, Palestine, Lebanon

INTRODUCTION

A key question of ecological biogeography is how far the geographical distribution of individual species of one ecological region extends into the ecotone bordering that region against another. The Levant contains the boundary between the mesic Mediterranean (sensu stricto) in its north and the semi-arid and arid Irano-Turanian and Saharo-Arabian in its south (YOM-TOV & TCHERNOV 1988). This boundary has long attracted the attention of biologists, including herpetologists (WERNER 1988; FEDERMAN & WERNER 2007).

A particularly interesting phenomenon concerns ‘northern’ species reported in the past from locations in northern Israel but now absent from that area, the distribution boundary apparently having receded northwards. This has been hypothetically explained as a result of the reduction in precipitation (WERNER 1988). One such case is

believed to be that of *Blanus strauchi aporus* F. WERNER, 1898, reported by LORTET (1883) and TRISTRAM (1885) as common in some places of present northern Israel, but never found in Israel by Israeli herpetologists despite targeted searches. In this case, no voucher specimen is known (WERNER 1988). The best documented case may be that of *Macrovipera lebetina obtusa* (DWIGUBSKY, 1832), that in the past occurred in northern Israel (BODENHEIMER 1957; JOGER 1984), but occurs here no more. One of us (YLW) examined four voucher specimens (Natural History Museum Vienna - NHMW 19929:1-4 from St. Jean d’Acre, now Akko, 1879, leg. PLASON). The trend of receding rainfall in that area is exemplified at Nahariyya, 10 km N of Acre, where the 30-year average annual precipitation has receded from 600-700 mm for 1921-1950 to 500-600 mm for 1931-1960 (ATLAS OF ISRAEL 1956, 1985).

THE PROBLEM

In this context, an open problem is posed in the southern Levant by *Natrix natrix* (LINNAEUS, 1758) (MARTENS 1996), widely distributed in the Palaearctic (BOULENGER 1913; THORPE 1979; KABISCH 1999). The evidence on its southern limit amounts to an intricate detective story. With the development of local biological research in the early 20th century, the then leading zoologists listed the snake under the name *Tropidonotus natrix* as occurring in the northern British Mandate of Palestine. Specifically, AHARONI (1912) said “*T. natrix* ... is very common ... was always caught by my Arabs in Wadi Kelt and ‘Ain Fara in the water, where it eats fish” (translated from German, YLW) (see map, Fig. 1). AHARONI (1929), reviewing the local snakes, said of *N. natrix*, “Its main habitat are wadis and rivers, where their stream is slow, marshes and wet thickets of reeds, and at the outlet of our rivers to the sea – also the salty seawater!” (translated from Hebrew, YLW). BODENHEIMER (1921, 1935, 1937), too, listed the species as occurring in the country, cautiously saying, “It is extremely rare.” (BODENHEIMER 1935: 186).

In fact, *N. natrix* (Fig. 2) was never encountered by the growing numbers of Palestinian, and later Israeli, biologists, herpetologists and amateurs. There is no

specimen of *N. natrix* from the Levant in the Herpetological Collection of the Hebrew University of Jerusalem, founded by AHARONI and containing much of his material. FLOWER (1933) commented, “*N. natrix*, has been reported from Palestine, but its occurrence there is doubtful.” WERNER (1939), quoting BÖTTGER (1878/79) (see below), suggested that Beirut seemed to be the southern limit of *N. natrix*, AHARONI & AHARONI (1941) excluded *N. natrix* from their key to local reptiles but that key was not planned to be complete. HAAS (1951) relied on WERNER (1939) and negated the presence of *N. natrix* in Israel. In the 1950s one suggestion, offered to explain the contradiction between the leading literature and the apparent facts, was that AHARONI might have mistaken a *Natrix tessellata* (LAURENTI, 1768) with seven supralabials, as sometimes happens (RAZZETTI et al. 2007) for *N. natrix*, and that BODENHEIMER respected his information.

Although *N. natrix* and *N. tessellata* are two well known distinct species, the identification of individual specimens can be difficult due to variation and at least occasional overlap of all pholidotic characters. It may be necessary to consider all characters together, and especially the trunk coloration.

THE SEARCH FOR EVIDENCE

Our investigation of the earlier literature unveiled a more likely and fascinating source for AHARONI’s (1929) possibly erroneous statement. The best known preceding authority on the Levant’s zoology, TRISTRAM (1884: 145) wrote “*Tropidonotus natrix* ... did not come under my own observation, but is reported from Palestine by BÖTTGER, Fr. MÜLLER, and BEDRIAGA. This is its furthest extension southwards and eastwards.” This statement may well have been AHARONI’s source but one wonders about the evidence that supports it. TRISTRAM (1866), and interestingly also LORTET (1883), mentioned of this genus only *N. tessellata* (or “*T. hydrus*”). Before them, HASSELQUIST (1766) mentioned no water snake at all.

TRISTRAM’s (1884) tome contains no bibliographic details. Of the three sources he mentioned, the most comprehensive and best known is BÖTTGER’s (1880) report on the herpetology of Syria, Palestine and Cyprus. His list of countries harboring *N. natrix* ends with “...bei Beyrut in Syrien (BÖTTGER, F. MÜLLER in lit.) und Palästina (v. BEDRIAGA) beobachtet worden.” The source “BÖTTGER” for Beirut presumably refers to his own 1877 paper because right under the headline of “*Tropidonotus natrix* L. sp. 1754” he says. “BÖTTGER, Syrien I, S. 287”. BÖTTGER (1877) reported on 16 reptiles from Syria, mainly snakes, including *N. natrix*, that had been sent to him for identification by Mr. Wilh. SCHLÜTER (merchant dealing with natural products)



Fig. 1: Physical map of the Levant, with some collection sites of *Natrix* spp. specimens mentioned in the text.

Abb. 1: Physische Karte der Levante mit Angabe der Fundorte von im Text erwähnten Exemplaren von *Natrix* spp.

- 1 – Martatros at Al Lathqiyah (NHMW 34740:8); 2 – Lake Homs (PERACCA 1894; MARTENS 1996);
- 3 – Beirut (NHMW 34740:10); 4 – Amiq swamp, southern Bekaa Valley (MARTENS 1996 fide IN DEN BOSCH);
- 5 – Afula (BMNH 1924.2.20.25); 6 – Yafo (SMF 17261); 7 – Wadi Qilt (AHARONI 1912);
- 8 – Jerusalem (NMB 660, 661); 9 – 'Ain Fara (AHARONI 1912).

in Halle a. d. S., according to whom all specimens (without exception) came from the northern environs of Beirut in Syria. BÖTTGER later (1878/79) repeated this list terming the locality of origin simply Beirut. There exists a voucher specimen of *N. natrix* from Beirut (NHMW 34740:10, Beirut, 1887, leg. Baron WARSBERG) (Fig. 3), and there is a report of two specimens brought by FESTA from Lake Homs in Syria ($34^{\circ}39'N$, $36^{\circ}34'E$), 130 km NE of Beirut (PERACCA 1894). Another report of *N. natrix* observed in southern Lebanon was recently contributed by Herman IN DEN BOSCH from the Amiq swamp area in the southern Bekaa Valley, approx. 40 km SE of Beirut (MARTENS 1996).

The source of MÜLLER for Beirut is thus a mere personal correspondence. There does exist, however, a reference of F. MÜLLER (1878: 602) to two *N. natrix* specimens from Jerusalem in the collection of the Natural History Museum of Basel (NMB), donated in 1878 by H. J. KOBER. The NMB contains the two, NMB 660 (pregnant female) and NMB 661 (juvenile; Fig. 4), but 'Jerusalem' is not part of the label but a typewritten catalogue entry with a handwritten question mark. An unsigned note in the catalogue says, "Both these specimens agree so extensively with our *Natrix natrix* from northern Germany, that no racial difference is visible" (Raffael WINKLER, pers. com., translated from German, YLW). Thus, there is some doubt whether they really originate from Jerusalem.

Hence, the source for Palestine, as distinct from Syria, remains BEDRIAGA. BEDRIAGA (1879) mentions *N. natrix* occurring in "Palästina", without voucher specimens or information source. Later BEDRIAGA (1882) writes that *N. natrix* is known, "... aus Vorder-Asien, wo er weit verbreitet ist." and gives as reference the BÖTTGER (1880) paper, rather than anything of his own. Therefore it comes to mind that perhaps BEDRIAGA (1879) relied on the earlier paper by BÖTTGER (1877).

Thus, it seems that BÖTTGER's (1877) *N. natrix* from Beirut, now in Lebanon, soon became reformulated as BEDRIAGA's (1879)

N. natrix from Palestine, at the time conceived as including Beirut (maps in TRISTRAM 1866; SEPP 1875). This reference to Palestine was quoted as such by BÖTTGER (1880), which was then quoted by TRISTRAM (1885), followed by AHARONI (1912, 1929) and BODENHEIMER (1921, 1935, 1937). Therefore, so far as this evidence goes, it is not necessarily the case that the distribution of *N. natrix* has retreated northwards; rather, the concept of Palestine has retreated southwards, leaving the Beirut specimen extralimital.

The question whether *N. natrix* occurs or occurred south of Beirut, in Palestine sensu stricto, was made yet foggier by HECHT (1930). In his review of the European species of the genus *Tropidonotus* he (1930: 329) said that (our translation) "In today's Syria and Palestine, *N. natrix* is known only

from very few specimens, e.g., from Jaffa and Jerusalem according to O. BÖTTGER (1879/1880)". The former reported having examined a specimen from Jaffa without mentioning the repository. HECHT (1930) did not list BÖTTGER (1879/ 1880) in the list of literature used, but referred the readers to DÜRIGEN (1897) and SCHREIBER (1912) for missing references; and the former references BÖTTGER (1879/ 1880).

This reference presumably is the one listed herein under BÖTTGER (1880), which, however, does not mention Jaffa or Jerusalem; it only says that BEDRIAGA (1879) had observed the species in Palestine. HECHT (1930) also attributed to BEDRIAGA (1879) the mention of a specimen from "Palestine (Jerusalem)" although BEDRIAGA (1879) had only mentioned Palestine.

THE EVIDENCE

There exist two voucher specimens of presumed *N. natrix* from Palestine (from the area now in Israel), and from the 20th century. First, MARTENS (1996) has drawn attention to a specimen at the Senckenberg Museum in Frankfurt, SMF 17261 from Jaffa, now Yafo ($32^{\circ}4'4''$ N, $34^{\circ}45'53''$ E), a juvenile collected in 1904 by the botanist A. KNEUCKER (Fig. 5). This specimen had in fact already been reported by ANDRES (1921), and was later described by MERTENS (1947) who, without explanation, hesitated to accept it as evidence ("Daß die Ringelnatter tatsächlich in Palästina vorkommt, möchte man trotz dem voliegenden, vom Botaniker A. KNEUCKER gesammelten Belegstück nicht mit Sicherheit behaupten"). This individual may well have been the Jaffa specimen mentioned by HECHT (1930: 329), however, he did not include it in the lists of *persa* or *syriacus* materials studied (1930: 264-267). Second, recently (Sept. 2008) Dr. Colin McCARTHY kindly has drawn our attention to a specimen in the Natural History Museum, London, BMNH 1924.2.20.25 from "Afulch, Palestine", a juvenile collected by Capt. P. A. BUXTON on 23 April 1923 (Fig. 6). The original handwritten labels of other specimens, from the same batch, show that the enigmatic locality "Afulch" stands for Afulch, now 'Afula ($32^{\circ}36' N, 35^{\circ}17' E$, 10 km S of Nazareth).

However, these two presumed Palestinian *N. natrix* specimens share some morphological details (Table 1). The supralabial count, although possible in *N. natrix*, is much more typical of *N. tessellata*, and to a lesser extent the same applies to the sublabial count. Most conspicuously, the light lunar spots, which presumably tipped the scales for previous identifiers in favor of *N. natrix*, are extraordinarily framed only dorsally by the black nuchal spots and thus remain open ventrad (Figs. 5, 6). Although this pattern occurred in no *N. tessellata* specimens ($n = 150$) throughout the area, from Austria and Italy in the west to Afghanistan in the east (including Lebanon and Syria), that we examined (Fig. 7), it does occasionally occur in *N. tessellata* in Israel, especially in juveniles (WERNER & SHAPIRA in MS). In both species, the coloration-contrast tends to decrease with age (GRUSCHWITZ et al. 1999; KABISCH 1999) and in *N. natrix* the white collar may eventually fade (STEWARD 1971). Also, the dorsal pattern of both specimens accords better with *N. tessellata*. (Lacking the pair of light stripes is irrelevant, because striped and non-striped *N. n. persa* can be clutch-mates - BODENHEIMER 1944). Therefore, the identification of SMF 17261 from Yafo and BMNH 1924.2.20.25 from Afula is herewith corrected to *Natrix tessellata*.

Table 1: Some morphological characters of *Natrix natrix* and *Natrix tessellata* of the museum specimens discussed. Numerical data are presented as left/right or as minimum-average (or mode)-maximum. PERCRA - percents of rostrum-anus length (WERNER 1971).

Tab. 1: Einige morphologische Merkmale der besprochenen Museumsexemplare von *Natrix natrix* und *Natrix tessellata*. Numerische Daten sind in der Form links/rechts oder als Minimum-Mittelwert (oder Modalwert)-Maximum angegeben. PERCRA - Prozentsatz an der Rostro-Anallänge (WERNER 1971).

Sample Untersuchtes Material	Locality Fundort	Light lunar spots Mondflecken	Dorsal color pattern Rückennuster	Tail length in PERCRA Schwanzlänge in PERCRA	Ventrals Ventralia	Subcaudal pairs Subkaudalia Paare	Supra- labials Supralabialia	Intra- labials Infralabialia
<i>N. natrix</i> (RAZZETTI et al., unpublished)	Europe (n = 23)	With posterior black frame	Variable, rarely tessellated	♂ 23-27-31 ♀ 18-22-26	♂ 173-176-182 ♀ 155-170-175	♂ 66-73-79 ♀ 46-58-68	5-7-8	9-10-11
<i>N. tessellata</i> (RAZZETTI et al., unpublished)	Levant (n = 76)	Rare, then open ventrad	Variable, mainly tessellated	♂ 18-25-29 ♀ 20-23-25	♂ 159-167-182 ♀ 157-162-170	♂ 48-65-77 ♀ 51-57-68	7-8-9	8-10-11
<i>N. natrix</i> NHMW 34740.8	Syria: Matatros	Posteriorly enclosed	<i>N. natrix</i> style + pair of lines	21.4	172	58	7/7	10/10
<i>N. natrix</i> NHMW 34740.10	Lebanon: Beirut	Posteriorly enclosed	<i>N. natrix</i> style + pair of lines	27.1	180	70	7/7	10/10
<i>N. tessellata</i> BMNH 1924.2.20.25	Israel: Afula	Open ventrad	Tessellated?	26.5	165.5	63	7/8	10/10
<i>N. natrix</i> NMB 660	Israel: Jerusalem?	Posteriorly enclosed, nearly meet dorsally	Tessellated or with spotless vertebral zone	23.7	176	60	7/7	10/10
<i>N. natrix</i> NMB 661	Israel: Jerusalem?	Posteriorly enclosed, nearly meet dorsally	Tessellated	28.6	175	74	7/7	9/9
<i>N. tessellata</i> SMF 17261	Israel: Yafö	Open ventrad, not approaching dorsally	Tessellated	23.9	164 *)	60	8/8	10/10

*) MERTENS (1947) erroneously reported 184 ventrals in this specimen. / MERTENS (1947) gibt irrtümlich für das Exemplar 184 Ventralia an.

Obviously the reports of both AHARONI (1912) and IN DEN BOSCH (MARTENS 1996) quoted above could have resulted from similar misidentification. At least AHARONI described his snakes as very aquatic and inhabiting also saltwater, which is more typical of *N. tessellata* (GRUSCHWITZ et al. 1999). The only voucher specimens of *N. natrix* from Israel, south of Lebanon, are the two labeled as originating from Jerusalem (NMB 660 and 661), a claim that cannot yet be confirmed or refuted. The past occurrence of *N. natrix* in Israel seems unproven, but must be taken into account as a possibility.

As far as known, *N. natrix* does not occur in Israel now. No later specimens are known, although after the establishment of the state, in 1948, systematic collection of reptiles, and especially snakes, has gradually intensified. Among the other herpetofaunal elements that are considered to have disappeared from

northern Israel (WERNER 1988), perhaps the case that is ecologically most comparable to *N. natrix* is that of *Emys orbicularis* (LINNAEUS, 1758). This species had been observed by LORRET (1883) in Lake Tiberias and from there also originates the latest convincing voucher specimen from Israel (Staatliches Museum für Naturkunde Stuttgart - SMNS 3808 from "See Genezaret", 1912, BERNECKER (FRITZ 1989)). Interestingly, this too comes from the early 20th century. In the second half of the 20th century the most southern voucher specimen seems to be ZFMK (Zoologisches Forschungsmuseum Alexander König, Bonn) 30536, from the Orontes River in northwesternmost Syria, "between Ain Krayem and Ain Taqa", 25 March 1980, R. KINZELBACH (KINZELBACH 1988; FRITZ 1993; BÖHME, pers. com.). The recent report of HRAOUI-BLOQUET et al. (2002) on Lebanon's herpetofauna excludes both *N. natrix* and *E. orbicularis*.

Figs. 2-7 (opposite page): Some of the *Natrix* spp. specimens mentioned in the text.
Scale bars represent 10 mm each. (Figs. 5 & 7 show the specimens' left side inverted for presentation.)
Abb. 2-7 (gegenüberliegende Seite): Einige der im Text erwähnten Exemplare von *Natrix* spp.

Die Balkenlängen entsprechen jeweils 10 mm.
(Abbildungen 5 & 7 sind gespiegelt wiedergegeben und zeigen die linken Körperseiten der Tiere.)

Fig. 2. Live juvenile *Natrix natrix* from Belgrad Ormani, Turkey, typical for the eastern subspecies *N. n. persa* (following MERTENS 1947). Note the light lunar spot (in this subspecies often yellow) framed posteriorly by the black nuchal spot. (The Hebrew University, Jerusalem - Reptile Collection HUJ-R 8966).

Abb. 2: Lebendes Jungtier von *Natrix natrix* aus Belgrad Ormani, Türkei, wie es typisch für die östliche Unterart *N. n. persa* (im Sinne von MERTENS 1947) ist.
Man beachte den hellen Lunarfleck (bei dieser Unterart öfters gelb), der von einem dunklen Nuchalfleck begrenzt wird. (The Hebrew University, Jerusalem - Reptile Collection HUJ-R 8966).

Fig. 3. *Natrix natrix* from Beirut: NHMW 34740:10, leg. Baron WARSBERG, 1887. The nuchal spot branches caudad. Note the pair of dorsal light stripes, occurring on most *N. n. persa* individuals.

Abb. 3: *Natrix natrix* aus Beirut: NHMW 34740:10, leg. Baron WARSBERG, 1887. Der Nuchalfleck verbreitert sich nach caudal. Man beachte das Paar heller Rückenstreifen wie sie bei *N. n. persa* meist vorkommen.

Fig. 4. Juvenile *Natrix natrix* allegedly from Jerusalem: NMB 661, don. H. J. KOBER, 1878.
The nuchal spot extends ventrad.

Abb. 4: Juvenile, angeblich aus Jerusalem stammende *Natrix natrix*: NMB 661, don. H. J. KOBER, 1878.
Der Nuchalfleck erstreckt sich nach ventral.

Fig. 5. Juvenile *Natrix* sp. from Yafo: SMF 17261, leg. A. KNEUCKER, 1904, initially considered *N. natrix*, now reidentified *N. tessellata*. The nuchal spot extends caudad and frames the whitish lunar spot only dorsally. MERTENS (1947) reported in this specimen 184 ventrals but we counted only 164.

Abb 5: Das Jungtier von *Natrix* sp. aus Yafo: SMF 17261, leg. A. KNEUCKER, 1904, ursprünglich für *N. natrix* gehalten, erweist sich bei Nachbestimmung als *N. tessellata*. Der Nuchalfleck erstreckt sich nach caudal und begrenzt den weißlichen Lunarfleck nur dorsal. MERTENS (1947) berichtete, das Exemplar hätte 184 Ventralia, doch wir zählten nur 164.

Fig. 6. Juvenile *Natrix* sp. from 'Afula: BMNH 1924.2.20.25, leg P. A. BUXTON, 1923, initially considered *N. natrix persa*, now reidentified *N. tessellata*. The nuchal spot extends caudad and frames the lunar spot only dorsally.

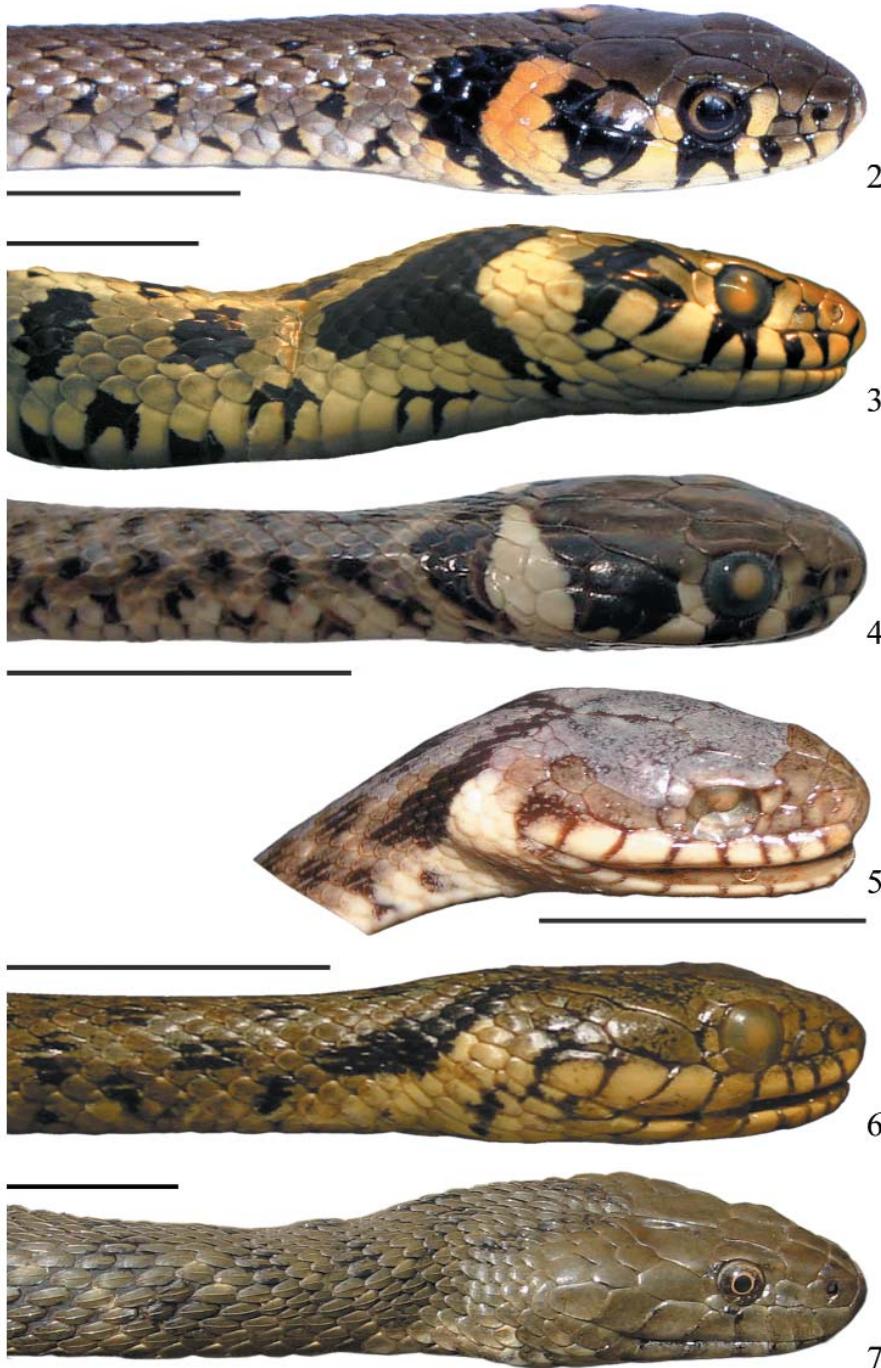
Abb. 6: Das Jungtier von *Natrix* sp. aus 'Afula: BMNH 1924.2.20.25, leg P. A. BUXTON, 1923,
ursprünglich für *N. n. persa* gehalten, erweist sich bei Nachbestimmung als *N. tessellata*.
Der Nuchalfleck erstreckt sich nach caudal und begrenzt den Lunarfleck nur dorsal.

Fig. 7. The common morph of *Natrix tessellata* that lacks the lunar and nuchal spots pattern.

Live adult specimen from Hellenental valley near Baden, Austria.
Abb. 7: Gewöhnlich hat *Natrix tessellata* keine Lunar- und Nuchalflecken.
Lebendes erwachsenes Exemplar aus dem Hellenental bei Baden, Österreich.

The southern limit of *Natrix natrix* in the Levant

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INTERPRETATION

The putative northward retreat of both *N. natrix* and *E. orbicularis* may be related to environmental changes. The climatic history of the area is poorly documented but is known as complex and replete with fluctuations (GOLDREICH 2003). Nevertheless, assorted lines of evidence indicate a reduction in wet habitats, due to two circumstances. First, a long-range trend of receding rainfall in northern parts of Israel. For example, at Nahariyya, 10 km N of Acre, site of the past occurrence of *Macrovipera lebetina*, the 30-year average annual precipitation has receded from 600-700 mm for 1921-1950 to 500-600 mm for 1931-1960 (ATLAS OF ISRAEL 1956, 1985). At Jerusalem, near the locations of AHARONI's (1912) sightings of *N. natrix*, the annual average for 1890-1912 was 628 mm, but for 1913-1940 only 486 mm (NEUMANN 1986). An overall effect of this trend is expressed in the water level of the Dead Sea, which has gradually receded over the last thousand years (GOLDREICH 2003).

Second, an artificial reduction of wet habitats, especially draining of swamplands. Swamps were very abundant in the lowlands of northern Palestine until the 1920s. But from 1922 onwards, swamps were grad-

ually systematically drained (JEWISH AGENCY FOR PALESTINE 1936; SALITERNIK 1942; YOM-TOV & MENDELSSOHN 1988), culminating with the draining of the Hula lake and drying its swamp during the 1950s, completed in 1958 (KARMON 1960; DIMENTMAN et al. 1992). Incidentally, the eradication of the long-standing local population of *Crocodylus niloticus* LAURENTI, 1768 (BÖTTGER 1880; TRISTRAM 1885; HAAS 1951) around the beginning of the century, attributed to hunting (YOM-TOV & MENDELSSOHN 1988), must have been finalized by swamp draining (HAAS 1951).

However, admittedly *Natrix tessellata* survives in most of northern Israel (WERNER & SHAPIRA, in MS), and *Mauremys rivulata* (VALENCIENNES, 1833), thrives here and even expands its range (GASITH & SIDIS 1983, 1984). Conceivably, the environmental changes have affected the competitive equilibrium between the two water snakes and between the two bog turtles. This itself may be a deserving research topic.

Finally, our experience demonstrates again the limitations and problematics of field observations, even by experienced researchers, that are not backed by museum specimens.

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